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THE APPLICATION OF MODAL LOGICS FOR THEORY BUILDING IN URBAN MORPHOLOGY AND SPACE SYNTAX

Abstract: *Urban Morphology, developed by Muratori, Whitehand, Conzen and the School of Versailles, and Space Syntax, developed by Hillier and his colleagues are significant contributions for generating general understandings or theory building on built environments. In this article Roy Bhaskar's critical realistic model of science and Georg Henrik von Wright's account of explanation and understanding are used to assess the explanatory power of Space Syntax and Urban Morphology. In essence subsequent considerations will distinguish between a theory able to offer an explanation of phenomena and a theory proposing an understanding thereof. As concluded, Space Syntax can offer an explanation of changes in a built environment in terms of cause and effect, while Urban Morphology aims at an understanding of the meaning associated with the causes at issue. The first perspective concerns built form and function, while the latter one concerns built form and meaning.*

Keywords: *theory building, modal logics, explanatory power, theory of science.*

Two established research traditions

Building systematic theories on built environment is still in a beginning phase. My approach is to use elementary theory of science through the use of Georg Henrik von Wright's modal logics combined with Roy Bhaskar's models on how research can be described on “think”, “see” and “is” levels. Urban Morphology and Space Syntax are established research approaches with a rich amount of worldwide research results. Therefore, the explanatory power of these contributions will be revealed.

On the one hand research within the Urban Morphology tradition aim at an understanding of the order and meaning of physical elements of a built environment. Here researchers are concerned with “intrinsic properties” of space, relying on things we can see; the shape, size, volumes, and textures of physical objects or a built mass (Hillier, 1999b). They consist mostly in geometrical properties and are responsible for the different *phenotype* each settlement has. Describing and illustrating the intrinsic properties of space is closely intertwined with meaning and intentions. Firstly, a physical object's purpose is important at the time it was made. Then, this object's presence throughout the years depends on the collective memory attached to it. Therefore, intrinsic properties of space account for the inter-relationship between built form and *meaning* (Marcus, 2000, p. 40).

On the other hand Space Syntax theory and methods contribute to a systematic explanation of spatial configurational relationships between the physical elements of a built environment. Research of this kind thus concerns “extrinsic properties” of space, whereas settlements are regarded as sets of spaces. Volumes, textures and size are not taken into consideration. Spaces are shape-free. It is just their inter-relational structure that counts here, revealing a built environment's *genotype*. Each space has one or more functions either for occupation or movement. Research concerning extrinsic properties of space is about built form and *function* (Marcus, 2000, p. 40).

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In a sense Urban Morphology and Space Syntax are complementary approaches. For Space Syntax research can to some extent use positivist scientific methods, while research in the Urban Morphology tradition presupposes a hermeneutic approach. As will turn out both these research traditions use different models of casual explanation.

The explanatory power of statements

Casual explanation models are dependent on two epistemological traditions of scientific methods. The *positivist* tradition emphasises the identification of the causes of effects, and has a high degree of *predictability*. The *hermeneutic* tradition emphasises explanations that search for an *understanding* beyond the phenomena. Causal explanations in a positivist perspective are simply labelled *explanations* while in the hermeneutic case they are labelled *understandings*. In the first case an explanation relates to *sufficient* conditions accounting for the causes of certain effects. In the second case understanding results from an assessment of *necessary* conditions reasonably associated with causes (von Wright, 1971, p. 1-4).

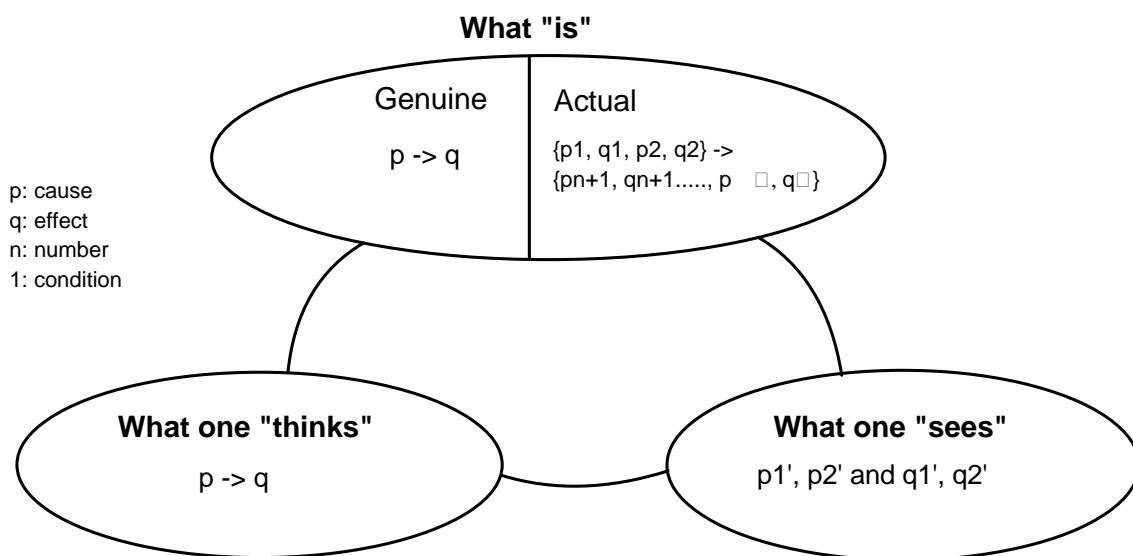


Figure 1. Troye's explanation model based on Bhaskar's model

Von Wright's proposed models of scientific explanation and understanding comply with Bhaskar's critically realistic model. Troye draws a model (figure 1) of different explanation levels based on Bhaskar's critically realistic model (Troye, 1994, p. 132). Consider a cause to be p and an effect to be q . Their relationship can be conceived both on the "think" level and in the genuine part of the "is" level. Each separate cause $p1, p2$ etc. together with each matching effect $q1, q2$ etc. can be perceived on the "see" level. But one does not experience the relationship between them. But experiments and their theoretical presuppositions make possible to gain knowledge about the relationship between p and q presenting themselves in the actual part of the "is" level. One perceives each separate cause $p1$ and $p2$ with their matching effects $q1$ and $q2$. By adding an invisible condition, labelled $+1$ some presumptions about the effect qn from a future cause pn can be made. This presumption of future cause and effect is made on the basis of observations of existing cause and effects.

The model in figure 1 is appropriate for explanations belonging to the positivist tradition. Urban Morphology though would be represented inadequately in this model. However, integrating von Wright's model of understanding into Bhaskar's critically realistic model can adequately assess the explanatory power of Urban Morphology.

Urban morphology's contribution to understand urban changes

In the 1950's Muratori developed an understanding of urban architecture, based on the historical idealism of Benedetto Croce. As Muratori and Rossi claims, a city is conceived as a man-made object, developing historically. Parts of a city are taken to be artefacts. The history of a city can be read through these artefacts, representing a city's collective memory. Some artefacts, named primary elements, have a constitutive power to aggregate or accelerate the urban process (Rossi, 1983, p. 86).

While Muratori emphasises an understanding of the aesthetic aspects of urban artefacts through history, M.R.G. Conzen carried out historical investigations in morphological terms. The geography of the town plan consists of three distinct but integral elements: 1) the street and its street system, 2) the plot and its plot patterns, and 3) the building arrangement within these patterns. These elements are determined by two criteria: The original function and period of origin, and the social economic conditions in the time they were produced. The building pattern reflects an age and an economic and social history (Whitehand, 1981, p. 58).

Urban Morphology research consists in a hermeneutic approach, consisting in an understanding of the meaning and intentions of a built environment's artefacts. Existing artefacts influence the location, appearance and orientation of new ones. When new artefacts come into being, it is difficult to assess their constitutive potential for future developments. Therefore, research as regards Urban Morphology has to consider the history of a city. A scientific contribution based on Urban Morphology searches for causal explanations of the relationship between changes in society through time and their effects on urban elements, which presuppose an account of intentionality and teleological explanation models.

Research concerning Urban Morphology is context dependent. Therefore examples from specific cases are used.

Effect (consequences): The physical pattern of the area around Birmingham centre is influenced its ring road.

Cause (reasons): A ring road was constructed in the 1960's, which constituted the further development of the area around Birmingham centre.

The model lacks a certain degree of predictability. When constructing a ring road today, it is difficult to derive how it will influence Birmingham's further transformations. Research in the Urban Morphology tradition requires studying the past to acquire an understanding of the intentions, which led to the existence of certain primary elements or other artefacts. Interpretations concerning their meaning, purpose and their representation by collective memory are supposed to ensue from their contextualised appearance.

First the effects has to be identified, then the causes. Subsequently, in research traditions belonging under the human and social sciences, the aim is to understand the reasons, intentions or motives associated with these causes. In such cases, explanations as regards forthcoming effects like future city developments are not given. Accordingly, Urban Morphology research can merely state that certain changes will occur, though not tell in what way.

Rossi claims that a city is a manmade object, even a piece of art. Here he refers to the meaning "behind" the artefacts, and he claims that meaning is the artefacts' origin. Therefore, the key to Urban Morphology's explanatory potential lies in an understanding of meaning and intentions associated with causes and not in the way a straightforward account of the way they might condition effects.

Urban Morphology is an historical approach, involving that its explanatory power should be assessed through *necessary* conditions for that something became *possible*. Due to its temporal ordering the relationship between cause and effect is asymmetrical. Naturally, a primary element arises before an urban structure adapts itself thereto. In a sense primary elements cause the shape of an urban area. But it is impossible to predict how new primary elements will affect its future shape.

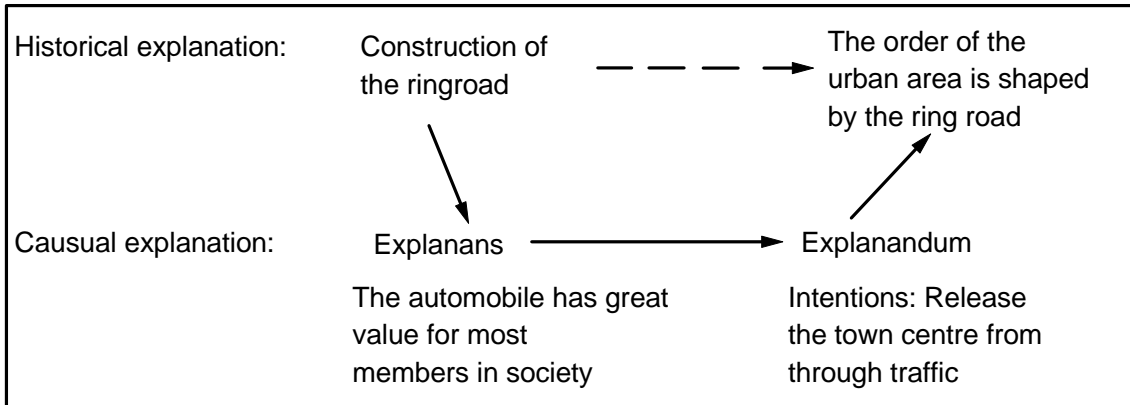
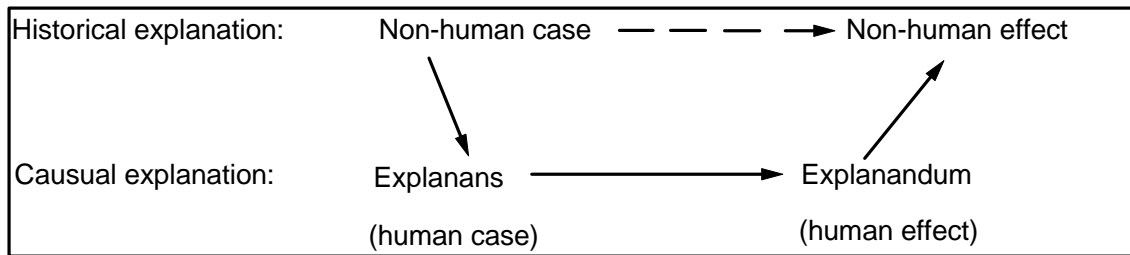


Figure 2. An example of teleological explanations

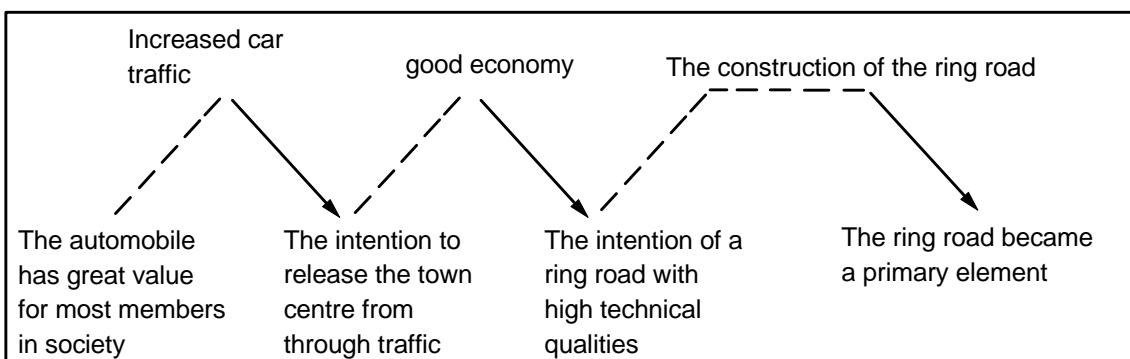
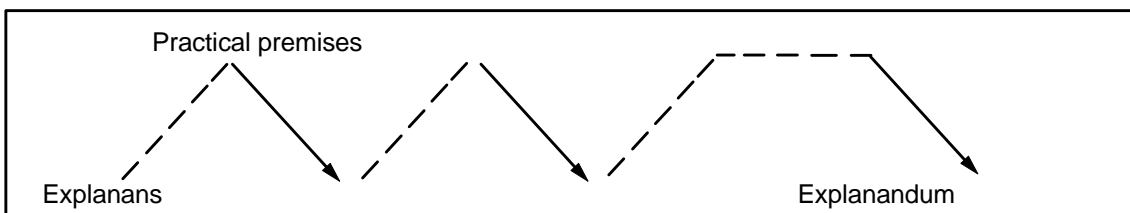


Figure 3. An instance of quasi-causal historical explanation

Human intentions or purposes and actual incidents often communicate with one another. Their nested interaction iterates. Von Wright illustrates quasi-causal historical explanations of this sort by the models presented in figure 2 and 3 (von Wright, 1971, p. 143). Each phase in an according process of understanding results in a new situation, which allows for new intentions and purposes. The process continues until the *explanandum* is reached. As these model show, Urban Morphology research requires asking what was necessary for something to become

possible. Historical incidents allow for further developments as they should transform intentions into effective action and, especially, by introducing new agents with new possibilities to influence their course.

Von Wright's modal logics focus on necessary and sufficient conditions. As Urban Morphology pertains to context dependent situations, the following disposition parallels these schemata with a particular instance.

Von Wright: p is a sufficient condition of q .

Urban Morphology: The intention to relieve the city centre from through traffic was a sufficient condition for the construction of Birmingham's ring road.

Von Wright: p is a necessary condition of q .

Urban Morphology: The intention to relieve the city centre from through traffic was a necessary condition for the construction of Birmingham's ring road.

The statement with necessary conditions is adequate. For an intention alone does not cause any particular action. However, it is difficult to assess as to whether the intention to relieve the city centre from through traffic was indeed a necessary condition for constructing Birmingham's ring road. It could be that other phenomena were necessary for its implementation, such as economical growth. A complex sufficient condition consists of a conjunction of states of affairs (von Wright, 1971, p. 39). Von Wright describes the situation by yet another scheme:

Von Wright: Maybe p or r alone is sufficient for that q will occur. But if p and r occur together, q is sure to be there too.

Urban Morphology: Maybe the intention to relieve the city centre from through traffic or economic growth alone is sufficient for the construction of Birmingham's ring road. But if the intention and economic growth occur both, then the construction at issue is sure to be there too.

Complex sufficient conditions thus are conjunctions, and, conversely, complex necessary conditions are disjunctions. In the case of sufficient conditions von Wright presents the relevant asymmetry by the following scheme, again instantiated by an example from Urban Morphology:

Von Wright: If p or r is sufficient for that q will occur, then p by itself is sufficient and so is r by itself.

Urban Morphology: If the intentions of relieving the city centre from through traffic or economic growth is sufficient for the construction of Birmingham's ring road, then the intention to relieve it from through traffic is itself sufficient.

Again, the examples indicate that in a hermeneutic context the assessment of sufficient conditions with relevant symmetry does not have explanatory power. Research in the Urban Morphology tradition is supposed to reconstruct the past and therefore has to search for intentions and purposes as conditions necessary for the development of an urban artefact. In what way artefacts of this sort influence the development of an urban area is too complex to be derived and depends on extra intentional factors. Neither can one predict as to whether a certain urban transformation will occur, nor can one assess how it will take place.

As all these examples of explanations show research in the Urban Morphology tradition does not lead to general statements on built environments due to its context dependency. A systematic analysis and interpretation of built form and meaning requires a hermeneutic methodology. For a society's ideologies, symbolic values, and attitudes constantly change and their articulation varies between cultures. Developing an understanding of both the artefact itself and its position in its comprehensive context and the intentions that necessarily conditioned their existence, destruction or alteration is needed. These can consist in political, economical, and societal circumstances as well as cultural preferences that were influential at that time the relevant artefacts came into being.

Figure 4 shows a revision of Troye's model from figure 1. The aim here is to search for an understanding of the meaning of a specific phenomenon p that caused q . It is impossible to say anything about how p caused q , even though it is possible to register q . A specific cause, labelled p' and its specific effect, labelled q' of a specific phenomena can be identified on the "see" level. On

the “think” level one is searching for an understanding of meanings and intentions members of a society had and that caused p' . This level represents the necessary conditions of the cause p' . The genuine part of the “is” level represents the invisible necessary conditions for the meaning and intentions for that the cause p' came into being. The way the particular cause p' and its effect q' , present themselves represents the actual part on the “is” level. The visible documentation of the identified necessary meanings, intentions and conditions that produced p' are also represented here.

Due to the context dependence of explanations belonging to a hermeneutic tradition, each p' with its according meanings and intentions has to be treated separately. The model in figure 4 cannot be used for gaining general statements on the relationship between meaning and intentions that caused p' .

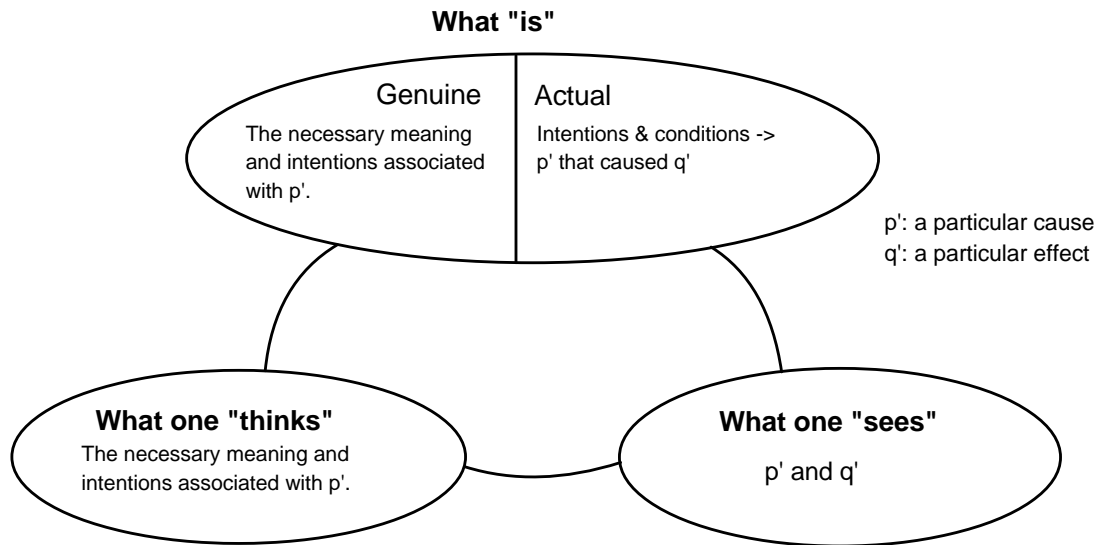


Figure 4. Troye's revised explanation model

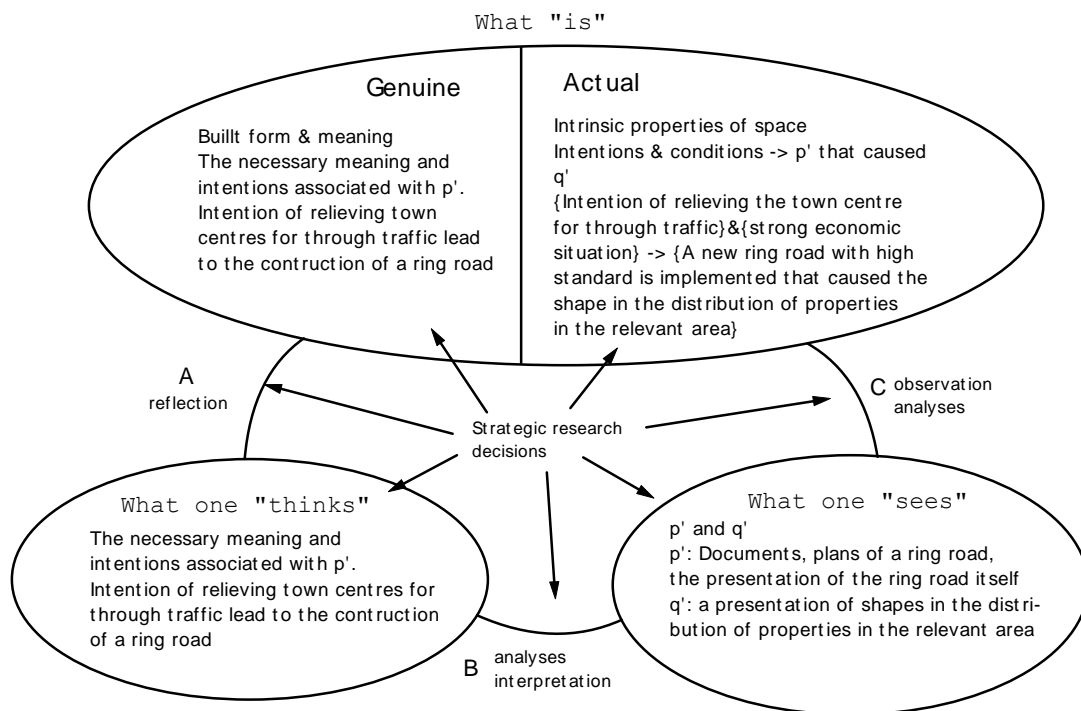


Figure 5. Urban Morphology's explanatory power through Bhaskar's model

Whitehand characterises the components of Conzen's analytical method as follows: First, intensive and accurate observation of geographical phenomena both in the field and on maps; secondly, the search for the processes producing such phenomena and the underlying forces involved; thirdly, unambiguous conceptualisation of observed phenomena on the basis of these processes and forces and in readiness for testing an improvement by comparative study; fourthly, the devising of an appropriate cartographic expression for concepts formed; and finally, the maintenance of an interdisciplinary perspective on any geographical problem (Whitehand, 1981, p. 9).

In an analogous manner Urban Morphology research concerning the relationship between Birmingham's ring road and its impact on urban changes would proceed along the following lines (figure 5): First one registers on the "see" level that the physical order of a particular urban area changed in consequence of a new road link. Here Birmingham's ring road as a primary element influenced the property pattern in Birmingham centre.

As regards meanings and intentions on the "think" level and in the genuine part of the "is" level, Birmingham's ring road link was built with the intention to relieve the town centre from through traffic. Likewise, technical changes such as an increase in car traffic or economic developments need to be registered. According hypotheses can be strengthened by data gathering on the "see" level such as e.g. studying old documents and plans from the time when the ring road was planned and constructed. In the actual part of the "is" level, one discovers how past developments in society influenced the present type and standard of a ring road. The ring road and the shape of the property pattern can be perceived, and the necessary intentions and conditions of the ring road can be identified from documents and plans of the ring road and by studying the history of technological changes.

Space Syntax' contribution to *explain* urban changes

During the last three decades, Hillier and his colleagues have developed a theory and a method consisting in calculating spatial relationships of the physical environment independent on various cultures. Results from research have contributed to some general statements on how built environments work. Primarily, cities are driven by two kinds of social forces: social-cultural and micro-economic ones. The creation of a city's space depends on socio-economic processes, but is not shaped exclusively by them. Presumably culture is a variable that shapes the local textures of space in settlements (Hillier, 2001). Micro-economic forces affect the global spatial pattern, while social-cultural forces affect the local spatial pattern of settlements. As it turns out, Space Syntax research related to micro-economic forces are rooted in a positivistic scientific tradition, where as research related to social-cultural forces are rooted in a hermeneutic scientific tradition.

As worldwide research has shown, the highest flow of people and shops locate themselves along the most spatially integrated streets. The *theory of natural movement economic processes* is able to predict movement and locations of economic activities in cities (Hillier et.al. 1998). Human intentions are unambiguous regards movement and economic activities. People tend to take the easiest orientable route. Economic activities locate themselves along streets where most people move and along streets with an optimal strategic location to reach most of an area's potential customers.

However, Space Syntax has not been able to make general statements or to propose a theory on how spatially segregated urban areas will affect human behaviour in the future. Here, human intentions are at stake, and hence, a hermeneutic approach is required. An understanding of for example space and crime has to be derived from studying already established areas.

Space Syntax research complies with the positivist tradition in epistemology. While research in the Urban Morphology tradition is closely intertwined with human intentions behind the artefacts, the former variety of research seeks to explain how a city is set up as an object, irrespective of human precondition of causation. In principle, most Space Syntax research searches for explanation models for the relationship between built form and function. The explanatory power of Space Syntax research relates to causality and its explanation models instantiate a positivist methodology:

Effect (consequences): The spatial configuration of a city's street network is changed.

Cause (reasons): A new movement route has been established.

This causal model is solid as regards general phenomena. The model works well even in cases of context dependency, which shows that space syntax can be used in a general context.

Effect (consequences): The integration value of High Street has decreased.

Cause (reasons): The ring road changed the spatial configuration of the street network in Birmingham.

When applying necessary and sufficient conditions, general cases can be used:

Von Wright: p is a sufficient condition of q .

Space Syntax: A new road link is a sufficient condition for a change in the spatial configuration system.

Von Wright: p is a necessary condition of q .

Space Syntax: A new road link is a necessary condition for a change in the spatial configuration system.

A positivist explanation model requires sufficient conditions for explaining the relationship between cause and effect. A new road link effectively brings about changes in a given spatial configuration system. Other aspects too can result in configurable spatial changes. However, it is sufficient that only one of them comes into being. A complex sufficient condition consists in a conjunction of phenomena (von Wright, 1971, p. 39). Again von Wright's schematic description is paralleled with an example from Space Syntax:

Von Wright: Maybe p or r alone is sufficient for that q will occur. But if p and r occur together, q is sure to be there too.

Space Syntax: Maybe a new road link or a road blockage alone is sufficient for that spatial configurable change will occur. But if a new road link and a road blockage occur together, spatial configurable change is sure to be there too.

In a complex necessary condition p and r are logically separated from one another. While a complex sufficient condition consists in a conjunction of a phenomenon, a complex necessary condition presents itself as a disjunction. The subsequent example shows how Space Syntax accounts for complex necessary conditions:

Von Wright: Maybe r does not require the presence of p (unconditionally), nor the presence of q (unconditionally); but r may nevertheless require that at least one of the two, p or q , be present.

Space Syntax: Maybe spatial configurable change does not require the presence of a new road link (unconditionally), nor the presence of a road blockage (unconditionally); but spatial configurable change may nevertheless require that at least one of the two, a new road link or a road blockage, be present.

Here the second example appears to be adequate.

Space Syntax accounts for predictability and can be applied independently on various cultures. It relates to the built environment as an object as such, irrespective of preconditions such as human intentions and meaning. Figure 6 shows the explanatory power of Space Syntax in Bhaskar's critically realist model.

The "think" level and the genuine part of the "is" level represent a cause and effect explanation; how a new road link changes the structure of a street network. On the "see" level both effects and causes are identified through maps or models of an entire built environment in a before and after situation. It is possible to perceive each new road link, and the location of functions. An overview of an entire built environment's dispersal of function and street network is represented on models. In the actual part of the "is" level one can derive from a set of causes, here several new road links, and their matching effects, thus functional changes, how future new road links will affect the dispersal of functions.

The spatial outcome of different cultures can be calculated and compared. What all cultures have in common are economic activities. Therefore it is possible to make general statements on how activities of this kind react to spatial configurative changes.

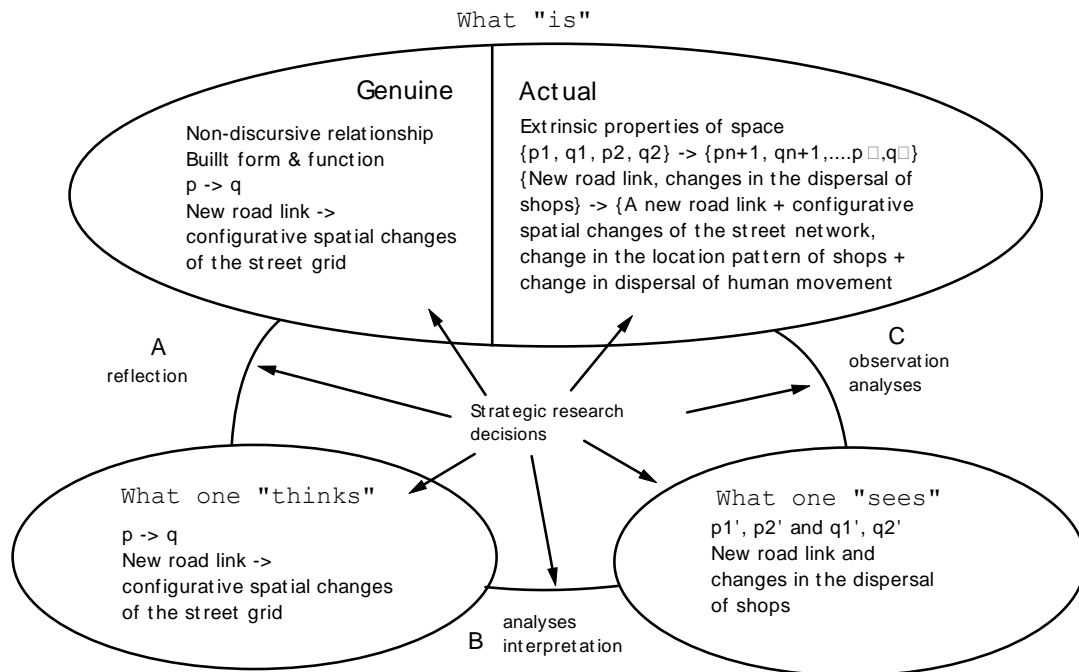


Figure 6. Space Syntax' explanatory power through Bhaskar's model

Understanding intrinsic and explaining extrinsic properties of space

Even though Urban Morphology and Space Syntax both try to gain scientific knowledge on urban transformation, their methods do not exclude one another. Urban Morphology research investigates changes with reference to intrinsic properties of space and assesses how these properties define the *order* and *pattern* of an urban area. Space Syntax research investigates changes in extrinsic properties of space and determines how they define the *structure* of an urban area.

Space Syntax seeks to *explain* phenomena while Urban Morphology seeks to *understand* them. In most Space Syntax research intentional explanations are left out of consideration. Due to their different explanation models Space Syntax and Urban Morphology adhere to different, though not opposite scientific traditions.

A juxtaposition of Urban Morphology and Space Syntax is more appropriate than a comparison. Urban Morphology accounts for meaning of order of physical form, while Space Syntax is concerned with structural spatial relationships shaped by physical objects. Moreover, Urban Morphology aims at an understanding of a city's static objects, while Space Syntax aims to explain movement and occupation possibilities through the structure of the network of urban spaces.

Gaining general knowledge on effects of physical spatial urban changes, research as in terms of Space Syntax seems more appropriate than any application of Urban Morphology. If, however, an investigation on how and why different types of artefacts came into being, the use of Urban Morphology seems more appropriate.

The theory of the natural movement economic process from Space Syntax research is able to *explain* the location of economic activities. One step further, a draft of a *theory on the natural urban transformation process* is already present. The aim is to *explain* how a natural urban

transformation processes occur. The street network configuration is steering degree of building density and degree of multi-functionality (Ye and van Nes 2014). In general, research concerning unambiguous human intentions makes stronger predictability on the socio-economic effects of spatial interventions than research dealing with complex context dependent cognitive as well as socio-cultural factors.

Most research on built environment has so far a strong hermeneutic approach. It accounts for place phenomenological approaches as well as for various morphological approaches. Space Syntax research concerning crime/anti-social behaviour, historical and archaeological sites, various social anthropological or cultural traditions' impact on urban space, and spiritual/religious activities in relation to space, requires also a hermeneutic approach.

As Juval Portugali writes, human beings are cognitive beings, where they can travel back and forward in time regards their memory. However, the physical outcome – the built environment – is the *media* of interaction (Portugali 2013, p. 3). Therefore, theory building on how built environments works and set the framework for socio-economic life for human beings requires being clear on the distinction between the physical form and the meaning, behaviour, memories etc attached to it.

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